# Schel-chélb Estuary

## 2003 Annual Monitoring Report

### Wetland Assessment and Monitoring Program


**Monitoring Staff**
**Jesse Barham**
**Jodie Beall**
**Fred Bergdolt**
**Tony Bush**
**Paul Dreisbach**
**Cyndie Prehmus**
**Bob Thomas**
**Tuesday Serra Shean**



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# Schel-chélb Estuary 2003 Annual Monitoring Report

For additional information about this report or the WSDOT Wetland Assessment and Monitoring Program, please contact:


Washington State Department of Transportation
Environmental Services Office
P. O. Box 47332
6639 Capital Boulevard South
Tumwater, WA 98504-7732

Fred Bergdolt, Wetland Monitoring Program Field Coordinator
Phone: 360-570-6645
E-mail: bergdof@wsdot.wa.gov

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## Executive Summary

This report summarizes project activities completed by the Washington State Department of Transportation (WSDOT) Wetland Assessment and Monitoring Program at the Schel-chélb Estuary mitigation site in 2003. Activities include vegetation and wildlife surveys. As specified in the *Operations, Maintenance, and Monitoring Plan* (*OMMP*) *for the West Harbor Operable Unit Wykoff/Eagle Harbor Superfund Site* (Hart Crowser 1997), formal site monitoring will resume in 2006, with distribution of the monitoring report by March 31 of the subsequent year. Informal, qualitative assessments of select wetland parameters including estimates of undesirable (invasive) species cover will occur in the summers of 2004 and 2005.

Vegetation surveys using the line intercept, point intercept, and point-frame monitoring methods were completed at the Schel-chélb Estuary in August 2003.[1] Though no vegetation performance standards were established for 2003, data were obtained to compare to Year 10 (2006) performance standards. Monitoring results indicate plant communities in the wetland buffer and intertidal salt marsh are well established. Data analysis shows native wetland plants provide 76% ($CI_{90\%}$ = 71-81%) aerial cover in the intertidal salt marsh zone. This estimate approaches the Year 10 (2006) performance standard that requires 85% vegetative cover.[2] The wetland buffer supports 65% ($CI_{90\%}$ = 58-73%) aerial cover of native trees and shrubs, which compares to the performance standard of 70% by Year 10 (2006). Aerial cover of undesirable (invasive) plant species was 6% ($CI_{80\%}$ = 5-8%), which meets the performance standard of less than 10% for Year 10 (2006). Though cover of invasive species remains low, weed control measures are ongoing. If current trends continue, these data suggest vegetation performance standards for Year 10 will be met in 2006.

Appendix A compares current development of vegetative communities in the intertidal salt marsh and upland zones to the original Schel-chélb planting plan. This comparison indicates plant communities in both zones are developing as intended.

Bird surveys were completed at the Schel-chélb Estuary on five dates from April through July 2003. The point count method was used to document both species richness and relative abundance. A diverse bird community was observed, with 41 species from 24 avian families present. Ten wetland-dependent species including several waterfowl, shorebird, and passerine species were recorded during these surveys. An additional four wetland-dependent shorebird species were recorded off survey. These species are the Great Blue Heron, Canada Goose, Mallard, Green-winged Teal, Bufflehead, Hooded Merganser, Greater Yellowlegs, Long-billed Dowitcher, Wilson's Snipe, Western Sandpiper, Least Sandpiper, Belted Kingfisher, Marsh Wren, and Red-winged Blackbird. Avian species diversity indices calculated for the Schel-chélb Estuary and Harper

[1] Methods are based on techniques described in Bonham (1989), Elzinga et al. (1998), Coulloudon et al. (1999), Krebs (1999), Zar (1999), and other sources.

[2] Most plant cover values are presented with their corresponding statistical confidence interval (CI). For example, the estimated aerial cover of native salt marsh plants is 76% ($CI_{90\%}$ = 71-81%) means that we are 90% confident that the true aerial cover value is between 71% and 81 percent.

reference sites show a statistically significant difference ($p = 0.010$), with higher values recorded for Schel-chélb. These results indicate that performance standards requiring similar bird species composition, richness, and diversity at the mitigation and reference sites in Year 10 (2006) have already been achieved.

Aquatic macroinvertebrate samples were collected from several locations across the Schel-chélb Estuary and Harper reference site in August 2003. Five invertebrate families were present in samples collected from each site. Though this result exceeds the Year 5 (2001) performance standard that requires invertebrate family richness values of at least 25 percent the number at the Harper reference site in Year 2 (1998), it does not meet the Year 10 (2006) performance standard that requires values of 50 percent. Thirteen aquatic macroinvertebrate families were identified from samples collected at the Harper reference site in 1998.

Aquatic macroinvetebrate sampling results from 2003 show much lower values for family richness at the Schel-chélb Estuary than in previous years (Bergdolt 1999 and 2000; WSDOT 2001). The apparent decrease in family richness may have been caused by damage to organisms in the 2003 samples, which was noted by the analyst. Organism damage is also suggested by the apparent decrease in family richness from 13 families in 1998 to only five families in 2003 for the Harper reference site. Aquatic macroinvertebrate samples will be collected from the Schel-chélb Estuary again in 2006.

Data collected from the Schel-chélb Estuary mitigation site and Harper reference site are available upon request from the Wetland Assessment and Monitoring Program

# Introduction

## Background

The Schel-chélb Estuary mitigation site serves as partial compensation for loss of aquatic habitat resulting from cleanup activities associated with the Wyckoff/Eagle Harbor Superfund Site. This restoration effort is located on the site of a historical estuary that was filled during road construction at the turn of the last century.

The Schel-chélb mitigation site is located approximately one-quarter mile west of Lynnwood Center on Point White Drive along the southwestern edge of Bainbridge Island, Washington. It is 2.1 miles southwest of the Superfund Site (Map 1, p. 4). This restoration project is part of the South Bainbridge Estuarine Wetland and Stream Relocation Project proposed by the U.S. Fish and Wildlife Service (USFWS) (Amato 1995). WSDOT is responsible for the mitigation plan and for the design, construction, and monitoring of the estuary. USFWS is responsible for the mitigation plan and for the design, construction, and monitoring of the stream restoration portion of the overall project. The Schel-chélb mitigation site is designed and constructed to be a naturally functioning estuarine wetland regardless of the success of the stream restoration project.

The Schel-chélb mitigation site is modeled after a small estuary near the town of Harper on the Kitsap Peninsula. From Schel-chélb, the Harper estuary is located 6.25 miles south across Rich Passage and approximately one mile northwest of the Southworth ferry terminal (Map 1, p. 4). The Harper wetland will be used as a reference site for comparisons of vegetative cover, soil texture and composition, bird use, and aquatic macroinvertebrates at the mitigation site.

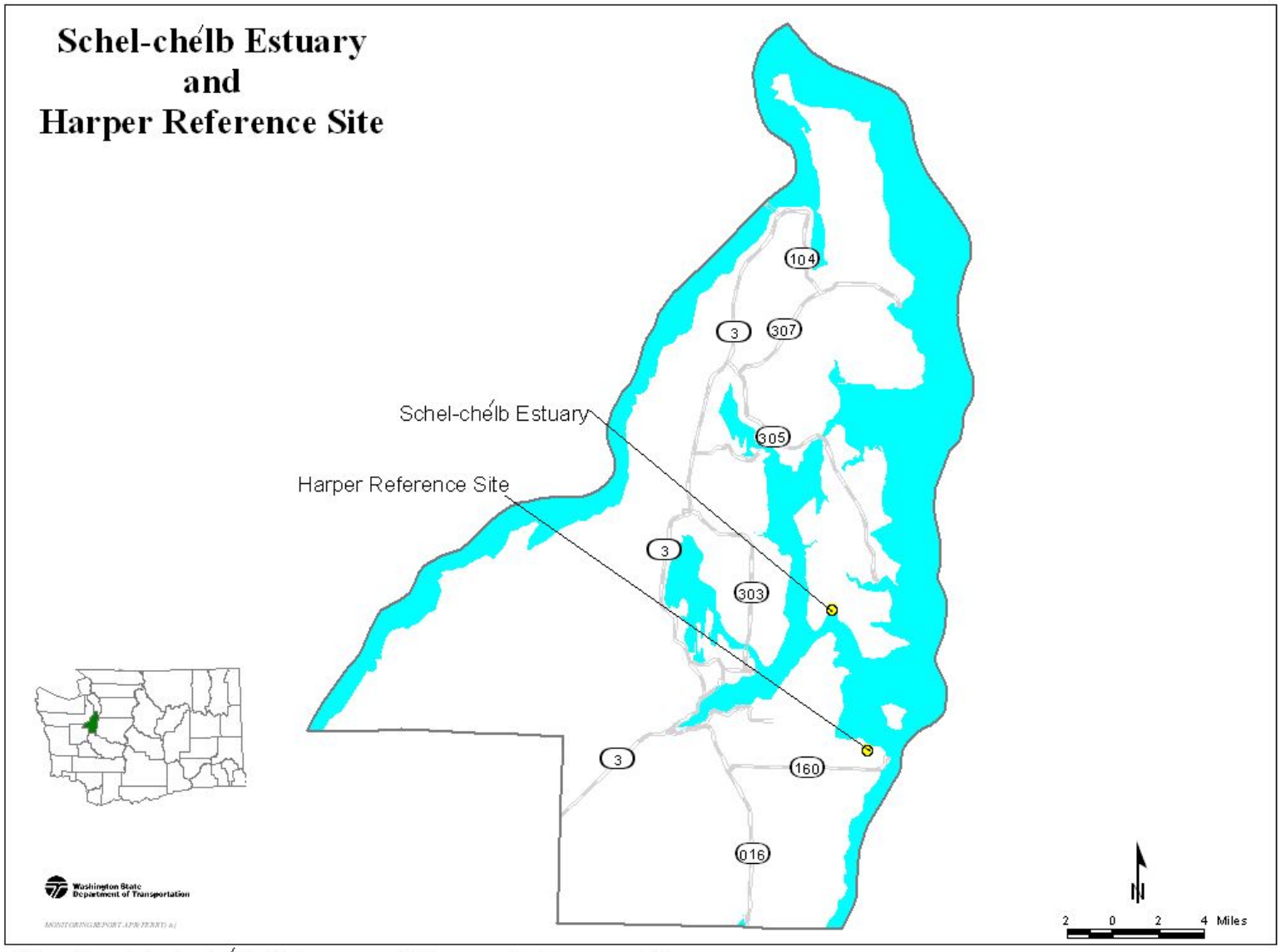
## Mitigation Site Description

The Schel-chélb mitigation site is intended to provide one acre of upland buffer and two acres of tidally inundated estuarine wetland. Inundation levels at the reference site were used to determine the location of planting areas in the constructed estuary. Schel-chélb has been divided into the following three zones:

- Intertidal flat – Approximately 34% of the wetland has been designed as intertidal flat with elevations below 10.0 feet mean sea level (MSL).
- Low intertidal salt marsh – Approximately 58% of the wetland has been designed as low intertidal salt marsh between elevations +10.0 and +12.5 feet.
- High intertidal salt marsh – Approximately 8% of the wetland has been designed as high intertidal salt marsh between elevations +12.5 and +13.0 feet.

The south end of the mitigation site is connected to Puget Sound via a 64-foot long, bottomless box culvert (12 feet wide and 6 feet high) that passes under Point White Drive and connects to Rich Passage. The restored stream at the north end of the mitigation site supplies freshwater to the estuary.

Privately owned land surrounds the estuary to the north, east, and west. Point White Drive borders the site along its southern boundary, separating the site from Rich Passage




**Map 1:** Schel-chélb Estuary and Harper Reference Site

to the south. Rural residences are present within several hundred meters of the site to the east and west. A mix of deciduous and coniferous forest surrounds these homes. The wooded area is most extensive to the north as it follows the restored stream.

## Objectives, Performance Standards, and Sampling Objectives

Year 7 (2003) performance standards are not included in the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998). To track site development, Year 10 (2006) performance standards for vegetation and wildlife were used to evaluate monitoring results from 2003. Site objectives and performance standards addressed in this report are listed below. Sampling objectives follow performance standards, where appropriate. Appendix B contains a complete text of the Goals, Objectives, and Performance Standards for the Schel-chélb mitigation site.

### Objective – Vegetation Communities

Replace an existing Category III wetland exhibiting low vegetative diversity and minimal wildlife use with a higher quality tidal wetland by restoring native tidal wetland plant communities of the type that historically existed on the site. The Harper estuary will be used as a reference for plant community development.

Performance Standard 1 (2006)
Areal (*sic*) vegetative cover of native salt marsh plants is at least 85% in the intertidal salt marsh.[3]

> Sampling Objective 1
> To be 80% confident the true aerial cover for native plants in the salt marsh is within 20% of the estimated value.

Performance Standard 2 (2006)
Areal (*sic*) vegetative cover of native trees and shrubs is at least 50% in the upland portion of the site.

> Sampling Objective 2
> To be 80% confident the true aerial cover for trees and shrubs in the upland is within 20% of the estimated value.

Performance Standard 3 (2006)
Areal (*sic*) coverage by undesirable aquatic species including cordgrass (*Spartina* spp.) is less than 10%.

[3] Objectives and performance standards are copied verbatim from the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998). Differences in the common usage of the terms *aerial* and *areal* have made their interpretation difficult. We feel the term *aerial* better describes the intent of the restoration plan in this case. Where we judge the word *areal* has been used arbitrarily in the performance standards, we follow it with a (*sic*) notation. The Glossary defines the meaning of these terms as used in this document.

Sampling Objective 3
To be 80% confident the true aerial cover for undesirable aquatic species is within 20% of the estimated value.

**Objective – Wildlife Habitat**

Provide intertidal habitat for wildlife species. Wildlife habitat for wetland dependent and other species will be increased as compared to the existing habitat value of the site. Creation of habitat will focus on increasing both habitat diversity (number of habitat types present) and habitat complexity (number and extent of canopy levels).

Perching, nesting, and foraging opportunities for passerine birds will be provided in the upland forested area. The intertidal salt marsh and the unvegetated flats will provide feeding areas for aerial-searching birds, shorebirds, and waterbirds.

Performance Standard 4 (2006)
The numbers and species and types of birds associated with salt marsh habitats will be similar to those observed at the Harper reference site in year one.

Performance Standard 5 (2006)
The number of bird species using the adjacent upland habitats will be at least two-thirds of the number using the Harper site in year one.

**Objective – Fish Habitat and Food Chain Support**

Provide an increase in habitat attributes (e.g., prey items, cover, overwintering area) for juvenile salmonids and other estuarine fish. Provide access for adult fish to the stream portion of the project by way of fish passage structures at the north end of the estuary.

Performance Standard 6 (2006)
Benthic invertebrate species richness is at least 50% of the number of species at the Harper site in year one.[4]

## Methods

Vegetation monitoring was conducted in August 2003. A temporary 154-meter baseline was placed along the eastern edge of the mitigation site. Thirty temporary sampling transects were placed perpendicular to the baseline using a systematic random sampling method (Figure 1, p. 8). Intertidal salt marsh and upland buffer zones were identified along each transect using a combination of topographic and vegetation indicators. Herbaceous and woody species cover data were collected along each transect. The mudflat and stream were not sampled.

[4] In an Addendum to the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998), the Environmental Protection Agency (EPA) and WSDOT agreed to identify to family specimens collected from the taxonomic categories *Polychaeta*, *Mollusca*, and *Crustacea*.

Aerial cover data for native emergent plant communities was collected using the point-frame method (Bonham 1989; Elzinga et al. 1998).[5] One hundred-nine point-frame sample unit locations were identified along transects in the intertidal salt marsh using a systematic random sampling method (Figure 1). A pin flag was lowered from above the tallest vegetation at 30 data collection points in each frame. Plant species intercepted by the pin flag were recorded. If the pin did not intercept a plant, the ground surface was recorded as bare soil, algae, or structure.[6] For each point-frame sample unit, a cover value was calculated based on the number of times target vegetation was encountered, divided by the total number of points per frame. Data points for bare soil, algae, and structures were subtracted from this total. For example, if native emergent plants are encountered on 15 points in a point-frame sample unit composed of 30 points, the aerial cover of native emergent species for that sample unit is 50 percent.

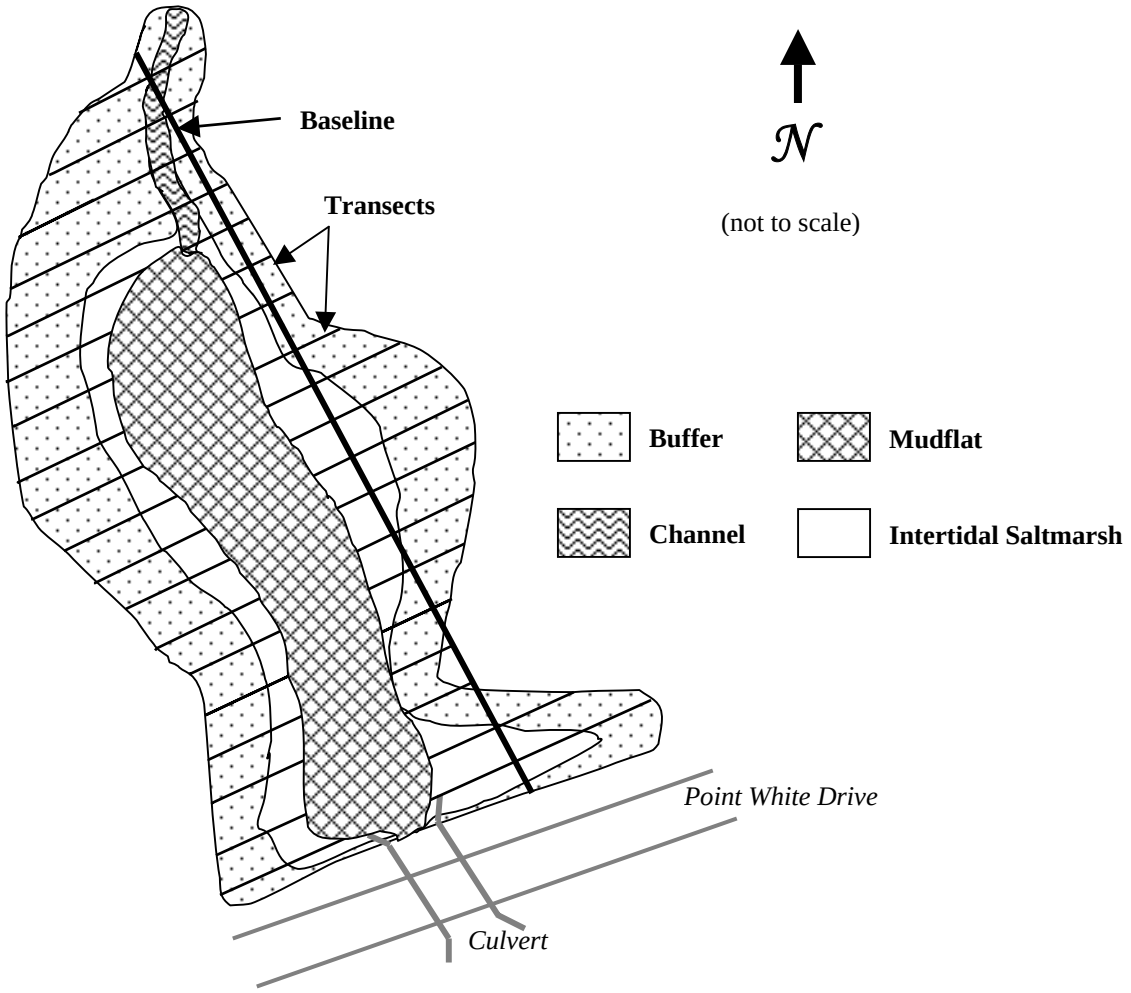
Aerial cover data for the woody plant community was collected using the line-intercept method (Canfield 1941; Bonham 1989). Eighty-one 10-meter line-segment sample units were placed along transects in the upland buffer using a systematic random sampling method (Figure 1). Native woody vegetation intercepting a tape measure extended the length of each sampling unit was identified and the lengths of canopy intercepts were recorded. To calculate an aerial cover value, the sum of the canopy intercept lengths was divided by the total length of the sample unit. For example, if woody species intercept eight meters in a 10-meter sample unit, the aerial cover for that sample unit is 80 percent.

To assess aerial cover of undesirable (invasive) species, the point-line method (Bonham 1989; Coulloudon 1999) was used. Following a random start, eighty-one 15-meter point-line sample units (60 points/unit) were placed along sampling transects in the upland buffer and intertidal salt marsh zones. A systematic random sampling method was used to position point-line sample units along transects (Figure 1). At each data collection point, a pin flag was lowered from above the tallest vegetation, and invasive plant species intercepted by the pin were recorded. For each sample unit, cover was calculated based on the number of points where invasive species were encountered divided by the total number of points per sample unit. For example, if invasive species are encountered on 6 points from a sample unit composed of 60 points, the cover of invasive species for that sample unit is 10 percent.

[5] The Monitoring Program typically uses a polyvinyl chloride (PVC) frame with strings that span the frame lengthwise. Points are marked on the strings using a standard randomization method.

[6] Aerial cover calculations include only areas covered by vascular plants (including floating-leaved species). For compliance purposes, areas covered by thallophytes, bryophytes, structures, or aquatic vegetation are not included in the calculations. Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2003).

**Figure 1 Schel-chélb Vegetation Sampling Design Sketch (August 2003).**



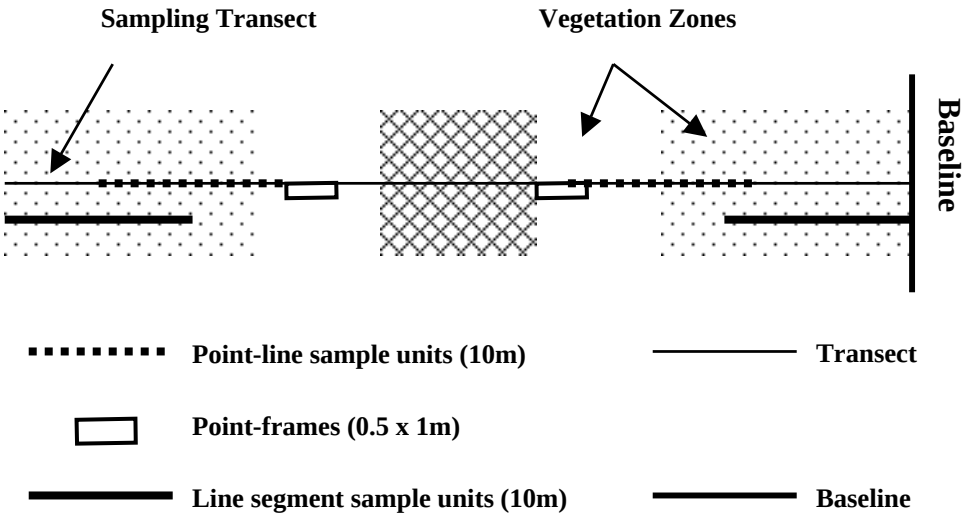



Table 1 provides details of the point-frame, line-intercept, and point-line vegetation sampling methods employed in 2003.

**Table 1 Vegetation Sampling Design Summary.**

| Performance Standard | Monitoring Method | Randomization Method | Sample Unit Dimensions | Units | Resolution |
|---|---|---|---|---|---|
| Emergent species cover | Point frame | Systematic | 1m × 0.5m | 109 | 30 points/unit |
| Woody species cover | Line intercept | Systematic | 10m lines | 81 | 0.1m gap rule[7] |
| Invasive species cover | Point-line | Systematic | 10m point-line | 81 | 60 points/unit |

Sample size analysis was conducted to determine if sufficient sampling had been completed to achieve the vegetation sampling objectives. The following equation was used to perform this analysis.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

$z$ = standard normal deviate
$s$ = sample standard deviation
$B$ = precision level[8]
$n$ = unadjusted sample size

A sample size correction to $n$ is necessary to adjust "point-in-time" parameter estimates.[9] The adjusted $n$ value reveals the number of sample units required to report the estimated mean value at a specified level of confidence.

Using the point count method (Ralph et al. 1993), five 10-minute bird surveys were conducted at the Schel-chélb and Harper estuaries between April and July 2003. Values for species richness and relative abundance were recorded.

Species diversity indices (H) were calculated for each of the data sets using the Shannon-Wiener function (Krebs 1999). A mean annual species diversity index was calculated.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

$H'$ = index of species diversity
$s$ = number of species
$p_i$ = proportion of sample belonging to $i$th species

The following $t$-test was used to test the null hypothesis that diversity indices from the Harper reference site and the Schel-chélb estuary are equal (Zar 1999).

$$t = \frac{H_1' - H_2'}{S_{H_1' - H_2'}}$$

$H'$ = index of species diversity
$S_{H_1' - H_2'}$ = standard error of the difference between species diversity indices $H_1'$ and $H_2'$

[7] Woody plants with canopy gaps less than 0.1m were considered continuous with no break in cover.
[8] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.
[9] Adjusted $n$ values were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al. 1998).

The Renkonen similarity index was used to further evaluate the degree of association or similarity in composition between bird communities at the Schel-chélb Estuary and Harper reference sites. The following equation was used in this analysis (Krebs 1999; Nur et al. 1999).

$$P = \sum_{i=1}^{i=S} \text{minimum}\left(p_i^A, p_i^B\right)$$

$p_i^A$ is the percentage of species $i$ in sample A
$p_i^B$ is the percentage of species $i$ in sample B
S is the number of species found in either sample

Macroinvertebrate sampling was conducted to evaluate prey resources important to juvenile salmonids and to provide a community level analysis. Samples were taken from several locations across the Schel-chélb Estuary and Harper reference sites. At both sites, aquatic macroinvertebrate samples were collected with a dip net from the water column both near the estuary outflow and in the stream to evaluate presence of fish prey species. Benthic macroinvertebrates in the intertidal flat were sampled from sediment taken with a standard tube sampler (clam gun) (Swanson 1978; Brooks and Hughes 1988). Samples were rinsed and filtered through a 0.5-millimeter sieve, then placed in a sample jar and preserved in alcohol for identification and analysis (McCafferty and Provonsha 1998).

Invertebrates were identified using a technical key (Voshell 2002). Following identification, these samples were archived for future reference. Macroinvertebrate sampling is designed to address family richness.

Incidental wildlife observations were recorded during all site visits.

## Results and Discussion

A baseline inventory was completed for the pre-existing Category III freshwater wetland prior to construction of the Schel-chélb Estuary mitigation site (Swanson et al. 1998). Records indicate the pre-existing wetland exhibited low vegetative diversity and minimal wildlife use. Signs of disturbance were reflected in the composition of the wetland plant community. Four species common to disturbed sites dominated the historical wetland. These species were *Rubus armeniacus* (Himalayan blackberry), *Pteridium aquilinum* (western brakenfern), *Equisetum arvense* (field horsetail), and *Vicia* spp. (vetch). Vegetation and wildlife monitoring results from 2003 indicate a higher quality wetland with increased wildlife use has replaced the degraded wetland that existed at this site prior to construction.

Vegetation surveys were completed at the Schel-chélb estuary in August 2003. Native plants in the intertidal salt marsh provide an estimated 76% ($CI_{90\%}$ = 71-81%) aerial cover (Figure 2). This estimate approaches the Year 10 (2006) Performance Standard 1 (Objective – Vegetation Communities) that requires 85% vegetative cover. As expected, a mix of fresh and saltwater tolerant species was observed. *Schoenoplectus maritimus* (cosmopolitan bulrush) and *Distichlis spicata* (seashore saltgrass) are most common in the high and low saltmarsh plant communities, respectively. Other species include *Agrostis exarata* (spike bentgrass), *Atriplex patula* (spear salt bush) *Deschampsia*

*caespitosa* (tufted hairgrass), *Juncus articulatus* (jointed rush), *Juncus ensifolius* (dagger-leaf rush), *Plantago maritima* (seaside plantain), *Salicornia virginica* (Virginia glasswort), and *Triglochin maritimum* (seaside arrow-grass).

Native tree and shrub species in the upland buffer provide an estimated 65% ($CI_{90\%}$ = 58-73%) aerial cover (Figure 3). This estimate approaches the Year-10 (2006) Performance Standard 2 (Objective – Vegetation Communities) that requires 70% cover of woody species. *Alnus rubra* (red alder) and *Salix sitchensis* (Sitka willow) provide most of the cover in the woody canopy, and have colonized large areas along the north and eastern edge of the mitigation site. Other native species observed include *Cornus sericea* (red-stemmed dogwood), *Crataegus douglasii* (black hawthorne), *Malus fusca* (Oregon crabapple), *Rosa nutkana* (Nootka rose), *Rosa pisocarpa* (peafruit rose), *Rubus spectabilis* (salmonberry), and Symphoricarpos albus (common snowberry).

Invasive (undesirable) species in the intertidal saltmarsh and upland zones combined provide an estimated aerial cover of 6% ($CI_{80\%}$ = 5-8%). This is less than the 10% aerial cover maximum specified for the Year-10 (2006) Performance Standard 3 (Objective – Vegetation Communities). An ongoing, aggressive weed control program implemented by local residents and WSDOT work crews has contributed to meeting this standard. *Spartina* species (cordgrasses) have not been found on the mitigation site. Table A-1 (Appendix A) includes invasive species observed on the mitigation site in August 2003.

Field observations and data analysis indicate upland and wetland plant communities are well established at the Schel-chélb Estuary. If current trends continue, final-year

**Figure 2** **Saltmarsh Plant Community** (August 2003).

**Figure 3** **Upland Buffer Plant Community** (August 2003).

vegetation performance standards will be met in 2006. Table 2 compares 2003 monitoring results to performance standards from Year-5 (2001) and Year-10 (2006).

**Table 2** **2003 Vegetation Monitoring Results Summary.**

| Standards | Year 5 (2001) | Year 7 (2003) | Year 10 (2006) |
|---|---|---|---|
| Native wetland plants in the intertidal salt marsh | 75% aerial cover | 76% ($CI_{90\%}$ = 71-81% cover) | 85% aerial cover |
| Native woody species in the buffer | 50% aerial cover | 65% ($CI_{90\%}$ = 58-73% cover) | 70% aerial cover |
| Invasive (undesirable) species | ≤ 10% aerial cover | 6% ($CI_{80\%}$ = 5-8% cover) | ≤ 10% aerial cover |

Appendix A compares current development of vegetative communities in the intertidal salt marsh and upland zones to the original Schel-chélb planting plan. This comparison indicates plant communities in both zones are developing as intended. Table A-1 (Appendix A) provides a complete list of plant species identified at the Schel-chélb Estuary in 2003.

Bird surveys were conducted at the Schel-chélb estuary and Harper reference site from April through July 2003. Ten wetland-dependent species including several waterfowl, shorebird, and passerine species were recorded during surveys at Schel-chélb. An additional four wetland-dependent shorebird species were recorded off survey. These species are the Great Blue Heron, Canada Goose, Mallard, Green-winged Teal, Bufflehead, Hooded Merganser, Greater Yellowlegs, Long-billed Dowitcher, Wilson's Snipe, Western Sandpiper, Belted Kingfisher, Marsh Wren, and Red-winged Blackbird.

By comparison, only three wetland-dependent species were recorded during surveys at the Harper reference site. In addition, while only one upland bird species was present during bird surveys at Harper, two were recorded at Schel-chélb.

Although observations and data analysis indicate similar types of birds are present at both sites (Renkonen Index = 0.514), values for species and family richness are greater for the Schel-chélb mitigation site. In addition, avian species diversity indices calculated for both sites show a statistically significant difference ($p = 0.010$), with higher values recorded for Schel-chélb. These results indicate Year 10 (2006) Performance Standards 4 and 5 (Objective – Wildlife Habitat) that require similar bird species composition, richness, and diversity at the mitigation and reference sites are likely surpassed at the Schel-chélb Estuary. Table 3 summarizes bird survey results for 2003.

**Table 3 Bird Survey Results** (April – July 2003).

| **Attribute** | **Schel-chélb Estuary** | **Harper Reference Site** |
|---|---|---|
| **Species Richness** | 41 species | 28 species |
| **Family Richness** | 24 avian families | 19 avian families |
| **Species Diversity Index** | | |
| Mean | 1.217 | 1.016 |
| Standard error | 0.050 | 0.125 |
| Range | 1.149-1.272 | 0.848-1.181 |

Habitat complexity may account for differences observed in bird species richness and species diversity at Schel-chélb and Harper (Milligan 1985; Finch 1989; Johnson and O'Neil 2001). While emergent, scrub-shrub, and upland habitats are present at the Schel-chélb Estuary, well-developed scrub-shrub and wetland buffer zones are largely absent from the Harper reference site. Vegetation monitoring results from the Harper reference site show the scrub-shrub community provides less than 10 percent aerial cover (Appendix C).

Records suggest the Schel-chélb Estuary provides habitat features that may attract wetland-dependent and upland bird species. Raptors, kingfishers, and passerine birds have been observed on many occasions using tall trees and habitat structures as perch sites along the perimeter of the wetland. Planted trees and shrubs including *Cornus sericea, Malus fusca and Rubus spectabilis* produce abundant fruit for birds and other wildlife. *Alnus rubra* and *Salix* species (willows) provide potential nest sites for passerine birds. Song Sparrows, Northern Flickers, and Killdeer have been observed nesting at the Schel-chélb Estuary.

Appendix D and E list species recorded during formal bird surveys at the Harper reference site and Schel-chélb Estuary from April through July 2003. Appendix E includes a checklist of birds recorded during survey and non-survey monitoring events at Schel-chélb from 1997 through 2003. This checklist shows the Schel-chélb Estuary attracts a wide variety of aerial-searching birds, shorebirds, waterfowl, and passerine species (Objective – Wildlife Habitat).

Aquatic macroinvertebrate samples were collected from several locations across the Schel-chélb Estuary and Harper reference site in August 2003. Five invertebrate families were present in samples collected from each site. Though this result exceeds the Year 5 (2001) performance standard that requires invertebrate family richness values of at least 25 percent the number at the Harper reference site in Year 2 (1998), it does not meet the Year 10 (2006) performance standard that requires values of 50 percent. Thirteen aquatic macroinvertebrate families were identified from samples collected at the Harper reference site in 1998.

Aquatic macroinvetebrate sampling results from 2003 show much lower values for family richness at the Schel-chélb mitigation site than in previous years (Bergdolt 1999 and 2000; WSDOT 2001). The apparent decrease in family richness may have been caused by damage to organisms in the 2003 samples, which was noted by the analyst. Organism damage is also suggested by the apparent decrease in family richness from 13 families in 1998 to only five families in 2003 for the Harper reference site. Aquatic macroinvertebrate samples will be collected from the Schel-chélb Estuary again in 2006.

Individuals from taxa known to be important to juvenile salmonids and indicators of pollution intolerance were identified in samples collected from the estuary in previous years (WSDOT 2001). These include families from the *Mollusca*, *Coleoptera*, *Megaloptera*, *Plecoptera*, and *Trichoptera* invertebrate orders (Objective – Fish Habitat and Food Chain Support).

## Management Activities

As part of the adaptive management plan for the estuary, weed control efforts in September 2003 focused on eradication of *Rubus* (blackberries) and *Cirsium* species (thistles). Thistles were bagged and removed to eliminate most of the seed.

Since monitoring results indicate the mitigation site is on track to meet Year 10 performance standards, other management activities were not initiated.

## Summary

The following table summarizes monitoring results from vegetation and wildlife surveys conducted at the Schel-chélb Estuary in 2003. Year 10 (2006) performance standards are included for comparison in this table.

**Table 4 Summary of 2003 Monitoring Results.**

| **Year 10 Performance Standard** (2006) | **2003 Monitoring Results** |
|---|---|
| Cover of native plants is at least 85% in the intertidal saltmarsh. | 76% ($CI_{90\%}$ = 71-81% cover) |
| Cover of native trees and shrubs is at least 70% in the upland buffer. | 65% ($CI_{90\%}$ = 58-73% cover) |
| Cover of undesirable species including cord grass is less than 10%. | 6% ($CI_{80\%}$ = 5-8% cover) |
| Numbers, species, and types of birds will be similar to those observed at the Harper reference site. | Avian species richness and diversity indices are greater at the Schel-chélb estuary. |
| Number of bird species using the adjacent upland habitats will be at least two-thirds the number at Harper. | Two upland bird species recorded at Schel-chélb. Harper records show only one. |
| Benthic invertebrate family richness is at least 50% of the number of species at the Harper site in year two (1998). | Five families present at the Schel-chélb Estuary (2003); 13 at Harper (1998)[10] |

[10] Aquatic macroinvetebrate sampling results from 2003 show much lower values for family richness at the Schel-chélb mitigation site than in previous years (Bergdolt 1999 and 2000; WSDOT 2001). The apparent decrease in family richness may have been caused by damage to organisms in the 2003 samples, which was noted by the analyst. Organism damage is also suggested by the apparent decrease in family richness from 13 families in 1998 to only five families in 2003 for the Harper reference site. Aquatic macroinvertebrate samples will be collected from the Schel-chélb Estuary again in 2006.

# Appendix A
# Plant Community Development at the Schel-chélb Estuary

## Introduction

The *Operations, Maintenance, and Monitoring Plan (OMMP) for the West Harbor Operable Unit Wykoff/Eagle Harbor Superfund Site* (Hart Crowser 1997) details the Washington State Department of Transportation's (WSDOT) responsibilities for construction, maintenance, and monitoring of the Schel-chélb Estuary mitigation site. Following an agreement with the Environmental Protection Agency (EPA), the OMMP was amended in 1999 to reflect changes in the planting schedule for the mitigation site. These changes are documented in the *Eagle Harbor Operations, Maintenance, and Monitoring Plan Update* (WSDOT 1999).

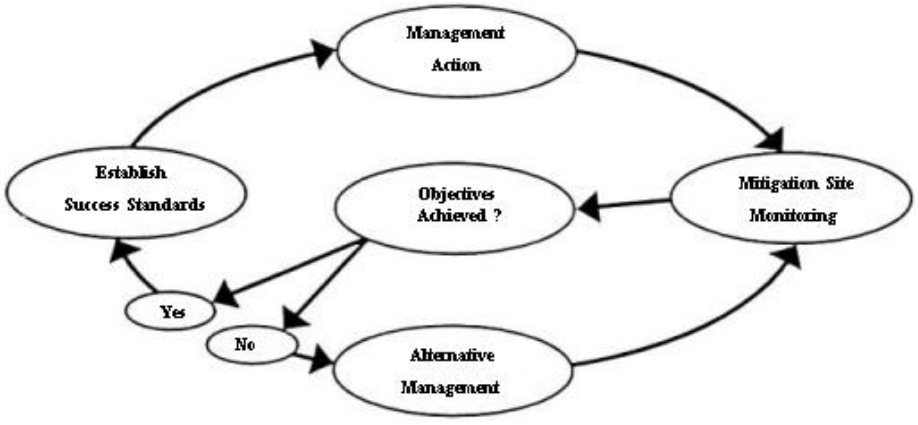
The Schel-chélb mitigation site is located on the site of a historical estuary that was filled as roads were constructed at the turn of the last century. During construction of the Schel-chélb estuary, opportunities arose to stockpile and replace existing topsoil. This topsoil had many dormant plant propagules that emerged shortly after mitigation site construction was complete. Rapid colonization of the mitigation site occurred. As a result, representatives from EPA and WSDOT agreed to implement a managed succession approach to revegetation of the Schel-chélb estuary.

## Adaptive Management

Active management may not be required if the Schel-chélb mitigation site is progressing toward its intended goals, objectives, and performance standards. When this is not the case, a mid-course correction may be necessary. Managed succession coupled with WSDOT's adaptive management plan provide a flexible and effective management strategy that helps ensure mitigation site success.

WSDOT's adaptive management plan follows the model illustrated in Figure A-1 (Elzinga et al. 1998). In this process: (1) performance standards are developed to describe some desired condition; (2) management activities are implemented to achieve

**Figure A-1** **The Adaptive Management Cycle** (Redrawn from Elzinga et al. 1998).



the desired performance standards; (3) the response of the resource is monitored to determine if performance standards have been met; and (4) management is adapted or changed if performance standards are not achieved. Monitoring is a critical component of the adaptive management process, providing the link between performance standards and site management activities.

The following describes the status of vegetative community development at the Schel-chélb Estuary. The discussion includes comparisons to the original planting plan.

**Site Objectives**

The primary goal of the Schel-chélb mitigation effort is to restore the historical intertidal estuary. A self-sustaining, functional wetland system with intertidal flat, saltmarsh, and scrub-shrub habitats is the intended result. A full text of the goals, objectives, and performance standards for this site are included in the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998) and in Appendix B of this report.

The original planting plan specifies three distinct zones of vegetation including an upland buffer with trees and shrubs, a riparian area dominated by shrubs, and a tidally influenced emergent wetland. Each of these zones is further divided based on anticipated soil conditions, hydrology, and aspect.

**2003 Results Compared to 2006 Requirements**

Field observations and data analysis indicate the scrub-shrub and emergent wetland plant communities intended for the estuary were well established in 2003. Species diversity and habitat complexity have increased as native woody and herbaceous plants continue to colonize areas of the mudflat, saltmarsh, riparian zone, and upland buffer.

Two shrub species included in the original planting plan have not been observed on the mitigation site. They are *Salix hookeriana* (Hooker's willow) and *Salix scouleriana* (Scouler's willow). However, many native species not present in the original planting plan have become established at the mitigation site. These species include *Fraxinus latifolia* (Oregon ash), *Alnus rubra* (red alder), *Crataegus douglasii* (black hawthorne), *Populus balsamifera* (black cottonwood), *Rubus spectabilis* (salmonberry), *Salix sitchensis* (Sitka willow), and *Symphoricarpos albus* (common snowberry).

In the emergent plant community, native sedge and rush species have colonized large areas of the intertidal flat and saltmarsh. Observed species include: *Carex lyngbyei* (Lyngby's sedge), *Carex stipata* (owlfruit sedge), *Juncus acuminatus* (tapertip rush), *Juncus articulatus* (jointed rush), *Juncus bufonius* (toad rush), *Juncus effusus* (common rush), *Juncus ensifolius* (sword leaf rush), *Juncus gerardii* (saltmeadow rush), *Juncus tenuis* (slender rush), and *Schoenoplectus maritimus* (cosmopolitan bulrush). These species were not included in the original planting plan.

Table A-1 provides a list of plants on the original planting plan and those observed during monitoring visits to the estuary in 2003. Reference to nativity, wetland status, and invasive status is included.

# Schel-chélb Estuary 2003 Plant List

**Table A-1 Species recorded at the Schel-chélb Estuary in August 2003.**

| Scientific Name[11] | Common Name | On Planting plan? | Invasive? | Observed in 2003? | Status | Nativity |
|---|---|---|---|---|---|---|
| *Agrostis exarata* | spike bentgrass | | | X | FACW | Native |
| *Agrostis gigantea* | redtop | | | X | FAC | NonNative |
| *Alnus rubra* | red alder | | | X | FAC | Native |
| *Anthoxanthum odoratum* | sweet vernalgrass | | | X | FACU | NonNative |
| *Argentina anserina* | silverweed cinquefoil | X | | X | OBL | Native |
| *Arbutus menziesii* | madrone | X | | | | |
| *Atriplex patula* | spear salt bush | X | | X | FACW | Native |
| *Camassia* sp. | camas | | | X | | |
| *Carex lyngbyei* | Lyngby's sedge | | | X | OBL | Native |
| *Cirsium arvense* | Canada thistle | | X | X | FACU+ | Non Native |
| *Cirsium vulgare* | bull thistle | | X | X | FACU | NonNative |
| *Convolvulus arvensis* | field bindweed | | X | X | NL | NonNative |
| *Cornus sericea* | redosier dogwood | X | | X | NL | Native |
| *Crataegus douglasii* | black hawthorne | | | X | FAC | Native |
| *Cytisus scoparius* | Scotch broom | | X | X | UPL | Non Native |
| *Dactylis glomerata* | orchard grass | | | X | FACU | Non Native |
| *Daucus carota* | Queen Anne's lace | | X | X | NL | Non Native |
| *Deschampsia caespitosa* | tufted hairgrass | X | | | FACW | Native |
| *Digitalis purpurea* | purple foxglove | | X | X | FACU | NonNative |
| *Distichlis spicata* | inland saltgrass | X | | X | FACW | Native |
| *Eleocharis parvula* | dwarf spikerush | | | X | OBL | Non Native |
| *Equisetum* sp | horsetails | | | X | | |
| *Festuca rubra* | red fescue | | | | FAC | Native |
| *Fraxinus latifolia* | Oregon ash | | | X | FACW | Native |
| *Grindelia integrifolia* | Puget Sound gumweed | | | X | FACW | Native |
| *Holcus lanatus* | common velvetgrass | | | X | FAC | Non Native |

[11] Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2003).

| Scientific Name | Common Name | On Planting plan? | Invasive? | Observed in 2003? | Status | Nativity |
|---|---|---|---|---|---|---|
| *Hypochaeris radicata* | hairy catsear | | X | X | FACU | NonNative |
| *Iris pseudacorus* | paleyellow iris | | X | X | OBL | NonNative |
| *Juncus acuminatus* | tapertip rush | | | X | OBL | Native |
| *Juncus articulatus* | jointed rush | | | X | OBL | Native |
| *Juncus bufonius* | toad rush | | | X | FACW+ | Native |
| *Juncus effusus* | soft rush | | | X | FACW | Native |
| *Juncus ensifolius* | swordleaf rush | | | X | FACW | Native |
| *Juncus gerardii* | saltmeadow rush | | | X | FACW+ | Native |
| *Leymus mollis* | American dunegrass | | | X | NL | Native |
| *Lolium arundinaceum* | tall fescue | | | X | FAC- | NonNative |
| *Malus fusca* | Oregon crabapple | X | | X | FAC+ | Native |
| *Mentha* arvensis | wild mint | | | X | FACW- | Native |
| *Phalaris arundinacea* | reed canarygrass | | X | X | FACW | NonNative/Native |
| *Phleum pratense* | timothy | | | X | FAC- | NonNative |
| *Plantago major* | common plantain | | | X | FAC+ | Native |
| *Plantago maritima* | goose tongue | | | X | FACW+ | Native |
| *Populus balsamifera* | black cottonwood | | | X | | Native |
| *Prunus sp.* | plum, cherry | | | X | | |
| *Rosa nutkana* | Nootka rose | X | | X | NI | Native |
| *Rosa pisocarpa* | cluster rose | X | | | FACU | Native |
| *Rosa sp.* | Rose | | | X | | |
| *Rubus armeniacus* | Himalayan blackberry | | X | X | FACU- | Non Native |
| *Rubus laciniatus* | cutleaf blackberry | | X | X | FACU+ | Non Native |
| *Rubus spectabilis* | salmonberry | | | X | FAC | Native |
| *Rubus ursinus* | California blackberry | | | X | NL | Native |
| *Rumex crispus* | curly dock | | | X | FAC+ | NonNative |
| *Salicornia virginica* | Virginia glasswort | X | | X | OBL | Native |
| *Salix hookeriana* | Hooker's willow | X | | | FACW- | Native |
| *Salix scouleriana* | Scouler's willow | X | | | FAC | Native |
| *Salix lucida* | Pacific willow | X | | X | FACW+ | Native |
| *Salix sitchensis* | Sitka willow | | | X | FACW | Native |

| Scientific Name | Common Name | On Planting plan? | Invasive? | Observed in 2003? | Status | Nativity |
|---|---|---|---|---|---|---|
| *Sambucus racemosa* | red elderberry | X | | | FACU | Native |
| *Schoenoplectus americanus* | American bulrush | | | X | OBL | Native |
| *Schoenoplectus maritimus* | cosmopolitan bulrush | | | X | OBL | Native |
| *Schoenoplectus tabernaemontani* | soft-stem bulrush | | | X | OBL | Native |
| *Sonchus arvensis* ssp. *arvensis* | field sowthistle | | X | X | FACU+ | NonNative |
| *Spergularia salina* | salt sandspurry | | | X | OBL | Native |
| *Stachys mexicana* | Mexican hedgenettle | | | X | FACW | Native |
| *Symphoricarpos albus* | common snowberry | | | X | FACU | Native |
| *Trifolium hybridum* | alsike clover | | | X | FACU+ | Non Native |
| *Trifolium pratense* | red clover | | | X | FACU | Non Native |
| *Trifolium repens* | white clover | | | X | FACU+ | Non Native |
| *Triglochin maritimum* | seaside arrow-grass | X | | X | OBL | Native |
| *Urtica dioica* | stinging nettle | | | X | FAC+ | NonNative/Native |

Figure A-2 represents the vegetation communities present at the Schel-chélb Estuary in August 2003. Data records and site observations show plant communities in the intertidal saltmarsh and upland buffer are developing as intended.

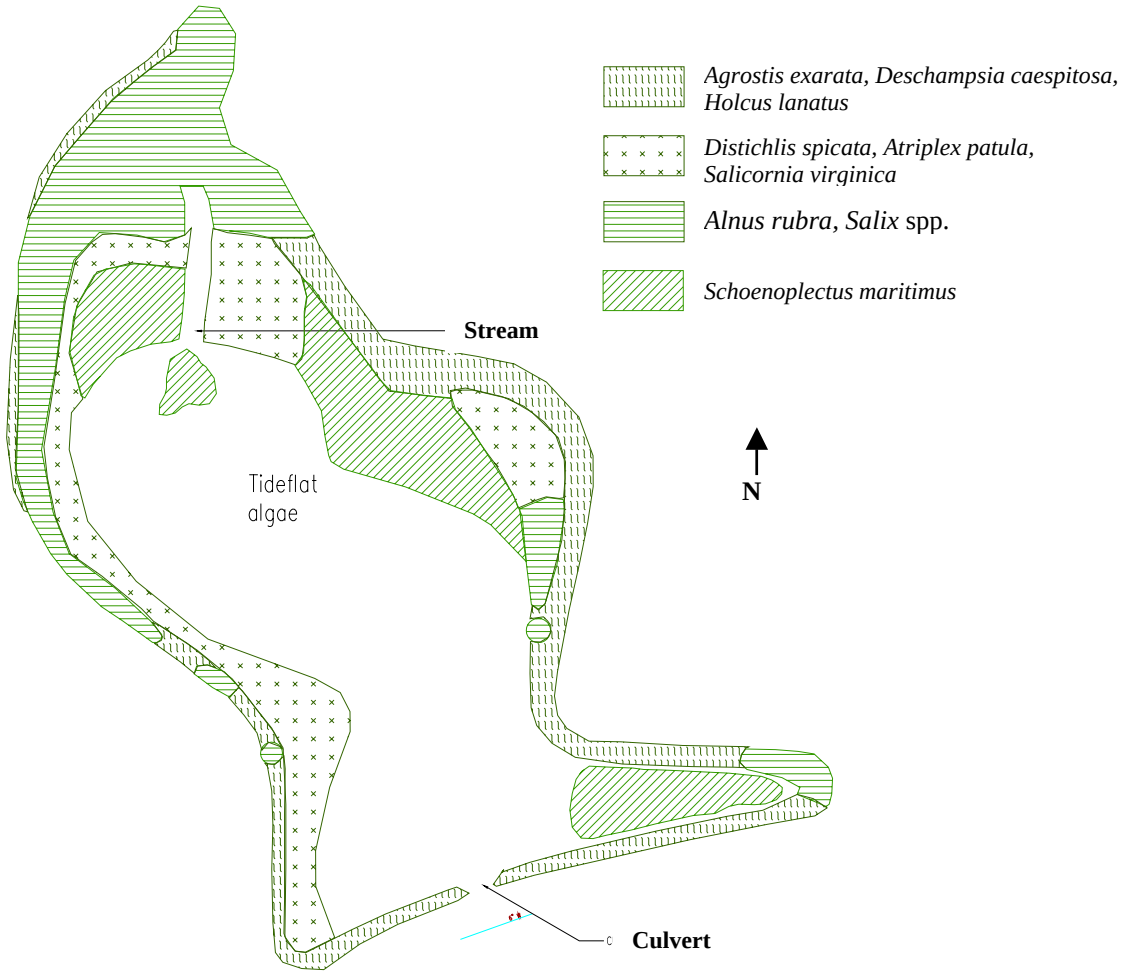



**Figure A-2** **Plant Communities at the Schel-chélb Estuary** (August 2003).

# Appendix B
## Goals, Objectives, and Performance Standards

The goals, objectives, and performance standards listed below are excerpted from the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998). Selected (**bold** font) Year-10 (2006) performance standards are addressed in this report. Companion sampling objectives follow where appropriate.

The primary goal of the Schel-chélb mitigation effort is to restore as closely as possible the intertidal and estuarine habitats that historically existed at this location. A self-sustaining, functional wetland system with intertidal flats and intertidal saltmarsh habitats is the desired outcome. This site is intended to provide wildlife habitat, fish passage, and food-chain support functions.

Amato (1995) enumerated ecological objectives for the estuary which have been reorganized into the five objectives below:

- Restore tidal conditions to approximately 2.0 acres of historical tidal wetland on Bainbridge Island.
- Replace an existing Category III wetland exhibiting low vegetative diversity and minimal wildlife use with a higher quality tidal wetland by restoring native tidal wetland plant communities of the type that historically existed on the site.
- Provide intertidal habitat for wildlife species.
- Provide an increase in habitat attributes (e.g., prey species, cover, overwintering area) for juvenile salmonids and other estuarine fish.
- Enhance an existing adjacent brackish marsh by improving tidal flow-through and removing barriers to fish passage between the project site and the existing marsh.

The Harper reference site was sampled during the first year of formal monitoring at the Schel-chélb estuary in 1998. Changes to WSDOT monitoring methods required re-sampling of the vegetative community using new monitoring techniques in 2001. Methods used to monitor the Harper estuary are described in Appendix B. Where indicated below, monitoring results from the Harper reference site will be used to evaluate site development at the Schel-chélb estuary.

**Objective 1:** Tidal Conditions
Restore tidal conditions to approximately 2.0 acres of historical tidal wetland on Bainbridge Island. This objective includes developing appropriate site elevations and a connection to marine waters at the estuary. Site topography, soil texture, salinity, tidal inundation patterns, and areal extent of vegetated areas will be measured for comparison with the design plans and measures at the Harper reference site.

**Performance Standards:**
At the end of the first year:

1. Topography - As-built plan sheets based on a survey of the site show the contours and elevation are constructed as shown on the design plans and results in a tidally inundated estuary of 2.0 acres or greater.
2. Salinity - Conductivity measured at high tide with a refractometer indicates a mixohaline environment.
3. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
4. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are similar to the design plans.

After 5 years:

1. Topography - A survey of the site shows a tidally inundated estuary of 2.0 acres or greater.
2. Soil Texture - Soil texture shows accumulation of fine silts and a change from sandy to silty sand substrate.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are within 15% of the design plan proportions.[12]

After 10 years:

1. Topography - A survey of the site shows a tidally inundated estuary of 2.0 acres or greater.
2. Soil Texture - Soil texture shows continued accumulation of fine silts.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are within 20% of the design plan proportions.

**Objective #2:** - Vegetation Communities
Replace an existing Category III wetland exhibiting low vegetative diversity and minimal wildlife use with a higher quality wetland by restoring native tidal wetland plant communities of the type that historically existed on the site. The Harper estuary will be used as a reference for plant community development.

**Performance Standards:**
At the end of the first year following construction:

1. At least two wetland classes, intertidal flat and intertidal saltmarsh, are established on the site.
2. The upland portion of the excavation site is planted with native tree and shrub species as specified in the Restoration Plan (Swanson et al. 1998).[13]

[12] Following an agreement with the Environmental Protection Agency (EPA), the OMMP was amended in 1999 to reflect changes in the planting schedule for the mitigation site (WSDOT 1999). These changes invalidate requirements in Performance Standard 5 (Objective 1) for monitoring Years 5 and 10.
[13] Evidence of plant colonization through all zones of the restoration site led to a proposed managed succession approach to revegetation of the estuary (WSDOT 1999). In May 1999, the planting schedule described in the Restoration Plan (Swanson et al. 1998) was amended to reflect this change.

After 5 years:
1. Areal vegetative cover of native saltmarsh plants is at least 75% in the intertidal saltmarsh.
2. Areal vegetative cover of native trees and shrubs is at least 50% in the upland portion of the site.
3. Areal coverage by undesirable aquatic species including cordgrass (*Spartina* spp.) is less than 10%.

After 10 years:
1. **Areal vegetative cover of native saltmarsh plants is at least 85% in the intertidal saltmarsh.**
2. **Areal vegetative cover of native trees and shrubs is at least 70% in the upland portion of the site.**
3. **Areal coverage by undesirable aquatic species including cordgrass (*Spartina* spp.) is less than 10%.**

**Objective #3:** - Wildlife Habitat
Provide intertidal habitat for wildlife species. Wildlife habitat for the wetland dependent and other species will be increased as compared to the existing habitat value of the site. Creation of habitat will focus on increasing both habitat diversity (number of habitat types present) and habitat complexity (number and extent of canopy levels).

Perching, nesting and foraging opportunities for passerine birds will be provided in the upland forested area. The intertidal saltmarsh and the unvegetated flats will provide feeding areas for aerial-searching birds, shorebirds, and waterbirds.

**Performance Standards:**
After 5 years:
1. The numbers and species and types of birds associated with saltmarsh habitats will be similar to those observed at the Harper reference site in year one.
2. The number of bird species using the adjacent upland habitats will be at least one-third of the number using the Harper site in year one.

After 10 years:
1. **The numbers and species and types of birds associated with saltmarsh habitats will be similar to those observed at the Harper reference site in year one.**
2. **The number of bird species using the adjacent upland habitats will be at least two-thirds of the number using the Harper site in year one.**

**Objective #4:** - Fish Habitat and Food-Chain Support
Provide an increase in habitat attributes (e.g., prey items, cover, overwintering area) for juvenile salmonids and other estuarine fish. Provide access for adult fish to the stream portion of the project by way of the fish passage structures at the north end of the estuary. Salinity, site topography, and soil texture measured under Objective 1 are important to providing appropriate fish habitat.

**Performance Standards:**
At the end of the first year following construction:
1. Topography - As-built plan sheets based on a survey of the site show the contours and elevation are constructed as shown on the design plans and results in a tidally inundated estuary of 2.0 acres or greater.
2. Salinity - Conductivity measured at high tide with a refractometer indicates a mixohaline environment.
3. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.

After 5 years:
1. Topography - A survey of the site shows a tidally inundated estuary with average slopes flatter than 7:1 (h:v).
2. Soil Texture - Soil texture shows accumulation of fine silts and a change from a sandy to silty sand substrate.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Benthic invertebrate species richness is at least 25% of the number of species at the Harper site in year one.[14]

After 10 years:
1. Topography - A survey of the site shows a tidally inundated estuary with average slopes flatter than 7:1 (h:v).
2. Soil Texture - Soil texture shows continued accumulation of fine silts.
3. Salinity - conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. **Benthic invertebrate species richness is at least 50% of the number of species at the Harper site in year one.**

**Objective #5:** - Fish Access to Marsh
Enhance an existing brackish marsh west of Baker Road by improving tidal flow-through and removing barriers to fish passage between the project site and the existing marsh. An existing culvert will be replaced with a 40-foot long 24-inch diameter culvert set at 0% slope and an invert elevation of +11.0 feet MLLW.

**Performance Standard:**
At the end of the first year following construction:
- The culvert under Baker Road shall be open and set at 0% slope and an invert elevation of +11.0 feet MLLW.

After 5 years:
- The culvert under Baker Road shall be open and provide fish passage at tidal elevations greater than +11.5 feet MLLW.

[14] Benthic macroinvertebrates will be identified to the taxon level family for *Polychaeta, Mollusca,* and *Crustacea*. All benthic macroinvertebrate samples collected at the Harper reference site and Schel-chélb mitigation site will be archived by WSDOT for future reference and identification to species as desired and/or agreed upon by WSDOT and EPA (Swanson et al. 1998).

After 10 years:

- The culvert under Baker Road shall be open and provide fish passage at tidal elevations greater than +11.5 feet MLLW.

# Appendix C
# Harper Reference Site

Data collected at the Harper reference site provides baseline information to measure progress of the Schel-chélb mitigation site in the fifth and tenth years of monitoring. The following summarizes monitoring methods and results for the Harper reference site.

**Monitoring and Sampling Objectives**

Monitoring Objective 1
Assess aerial vegetative cover of native saltmarsh plants in the intertidal saltmarsh.

> Sampling Objective 1
> To be 80% confident the true aerial cover estimate for native saltmarsh plants is within 20% of the estimated value.

Monitoring Objective 2
Assess aerial cover of undesirable (invasive) species for the entire site.

> Sampling Objective 2
> To be 80% confident the true aerial cover estimate for invasive species is within 20% of the estimated value.

Monitoring Objective 3
Assess aerial vegetative cover of native trees and shrubs in the upland buffer.

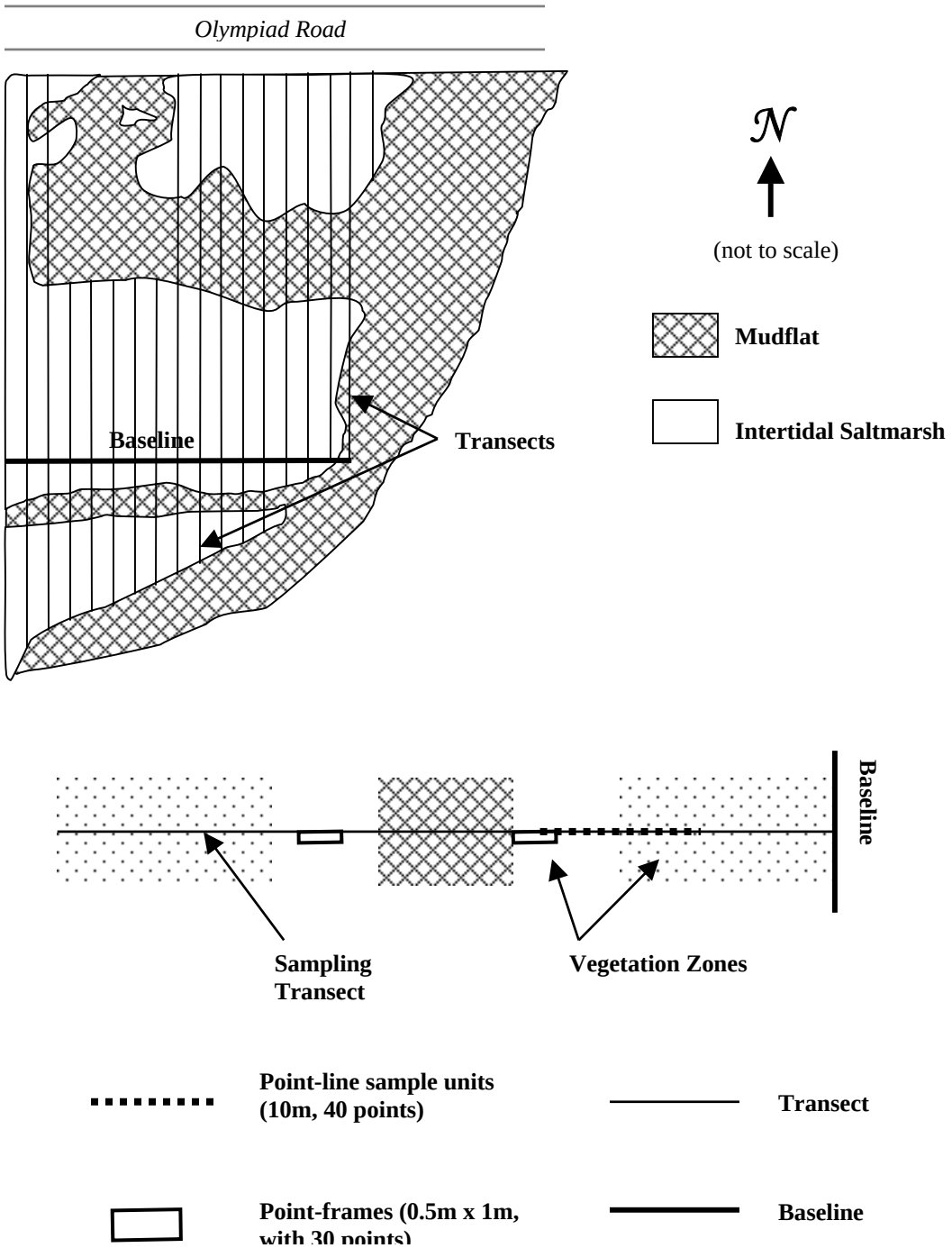
**Methods**
To assess vegetative attributes on site, a baseline was established east to west across the intertidal saltmarsh. Twenty sampling transects were located perpendicular to the baseline using a systematic random sampling method (Fig. C-1).

For the native emergent plant community, the point frame method (Bonham 1989; Elzinga et al. 1998) was used to collect aerial cover data. One hundred fifty-nine point frame locations were identified along sampling transects using a systematic random sampling method (Fig. C-1). Each frame (0.5m × 1m) contained 30 data collection points.

To assess cover of undesirable (invasive) species, the point-line method (Bonham 1989; Coulloudon 1999) was used to collect aerial cover data. Following a random start, eighty-five 10-meter point-line sample units (40 points/line) were placed along transects across the site using a systematic random sampling method (Fig. C-1).

For both point frame and point-line sample units, a pin flag was lowered from above the tallest vegetation at each data collection point. Plant species intercepted by the pin were recorded.

**Figure C-1 Harper Vegetation Sampling Design Sketch (August 2001).**



Sample size analysis was conducted to determine if sufficient sampling had been completed to achieve the sampling objectives. The following equation was used to perform this analysis (Elzinga et al. 1998).

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

$z$ = standard normal deviate
$s$ = sample standard deviation
$B$ = precision level[15]
$n$ = unadjusted sample size

A sample size correction to $n$ is necessary to adjust "point-in-time" parameter estimates.[16] The adjusted $n$ value reveals the number of sample units required to report the estimated mean value at a specified level of confidence.

A narrow zone of scrub-shrub vegetation surrounds the Harper reference site. Small size and patchy distribution make it difficult to assess cover in this zone quantitatively. Cover of native trees and shrubs in the upland zone was assessed qualitatively in 2001.

Using the point count method (Ralph et al. 1993), five 10-minute bird surveys were conducted at the Harper reference site from April through July 2001. Values for species richness and relative abundance were calculated.

Species diversity indices (H) were calculated for each of the five data sets using the Shannon-Wiener function (Krebs 1999). A mean annual species diversity index was calculated for the site.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

$H'$ = index of species diversity
$s$ = number of species
$p_i$ = proportion of sample belonging to $i$th species

The following $t$ test was used to test the null hypothesis that diversity indices from the Harper reference site and the Schel-chélb estuary are equal (Zar 1999).

$$t = \frac{H'_1 - H'_2}{S_{H'_1 - H'_2}}$$

$H'$ = index of species diversity
$S_{H'_1 - H'_2}$ = standard error of the difference between species diversity indices $H'_1$ and $H'_2$

Aquatic macroinvertebrate samples were collected from four locations across the estuary in 1998. The sampling protocol was designed to measure invertebrate prey resources important to juvenile salmonids and provide a community level analysis that is comparable to the mitigation site. Benthic macroinvertebrates in the intertidal flat were sampled from cores taken with a standard tube sampler (clam gun) (Swanson 1978;

[15] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.
[16] Adjusted $n$ values were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al. 1998).

Brooks and Hughes 1988). Invertebrate samples were rinsed and filtered through a 0.5mm sieve, then placed in a sample jar and preserved in alcohol for later analysis (McCafferty and Provonsha 1998).

Invertebrates were identified using a technical key (Plotnikoff and White 1996). Taxa known to be important to juvenile salmonids and indicators of pollution intolerance (e.g., *Polychaeta*, *Mollusca*, and *Crustacea*) intolerance were taken to at least the family level. Following identification, all invertebrate samples were archived for future reference.

Incidental wildlife observations were recorded during all site visits.

**Results**

Analysis of point-frame data shows cover of native saltmarsh species in the intertidal zone is estimated to be 99% ($CI_{99\%}$ = 98-100%) aerial cover. *Distichlis spicata* (inland saltgrass), *Salicornia virginica* (Virginia glasswort), and *Juncus gerardii* (saltmeadow rush) dominate this zone.

Low cover and a patchy plant distribution made quantitative estimates of undesirable (invasive) species and scrub-shrub cover impracticable. An ocular estimate of less than 10% was recorded for undesirable (invasive) species cover in the scrub-shrub and intertidal saltmarsh zones. The narrow upland buffer that surrounds the reference site provides less than 10% scrub-shrub cover.

Table C-1 lists plant species identified during monitoring visits to the Harper reference site in August 2001.

**Table C-1 Harper Reference Site Plant List** (August 2001).

| Scientific Name[17] | Common Name | Status | Nativity |
|---|---|---|---|
| *Acer macrophyllum* | bigleaf maple | FACU | Native |
| *Agrostis capillaries* | colonial bentgrass | FAC | Non Native |
| *Agrostis exarata* | spike bentgrass | FACW | Native |
| *Agrostis gigantean* | redtop | FACW | Non Native |
| *Alnus rubra* | red alder | FAC | Native |
| *Argentina anserine* | silverweed cinquefoil | OBL | Native |
| *Atriplex patula* | spear salt bush | FACW | Native |
| *Carex lyngbyei* | Lyngby's sedge | OBL | Native |
| *Cirsium vulgare* | bull thistle | FACU | Non Native |
| *Convolvulus arvensis* | field bindweed | NL | Non Native |
| *Cuscuta salina* | saltmarsh dodder | NL | Native |
| *Cytisus scoparius* | Scotch broom | UPL | Non Native |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | Native |
| *Distichlis spicata* | inland saltgrass | FACW | Native |
| *Elymus repens* | quackgrass | FACU | Non Native |
| *Festuca rubra* | red fescue | FAC | Native |
| *Grindelia integrifolia* | Puget Sound gumweed | FACW | Native |
| *Hedera helix* | English ivy | NL | Non Native |
| *Holcus lanatus* | common velvetgrass | FAC | Non Native |

[17] Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2003).

| | | | |
|---|---|---|---|
| *Hordeum brachyantherum* | meadow barley | FACW | Native |
| *Hordeum jubatum* | foxtail barley | FAC+ | Native |
| *Hypochaeris radicata* | hairy catsear | NL | Non Native |
| *Jaumea carnosa* | marsh jaumea | OBL | Native |
| *Juncus gerardii* | saltmeadow rush | FACW+ | Native |
| *Lathyrus sylvestris* | flat pea | NL | Non Native |
| *Plantago lanceolata* | narrowleaf plantain | FACU+ | Non Native |
| *Plantago maritime* | goose tongue | FACW+ | Native |
| *Polygonum aviculare* | prostrate knotweed | FACW- | Non Native |
| *Polygonum cuspidatum* | Japanese knotweed | NL | Non Native |
| *Pseudotsuga menziesii* | Douglas-fir | NL | Native |
| *Rosa nutkana* | Nootka rose | NL | Native |
| *Rubus armeniacus* | Himalayan blackberry | FACU- | Non Native |
| *Rubus laciniatus* | cutleaf blackberry | FACU+ | Non Native |
| *Rubus spectabilis* | salmonberry | FAC | Native |
| *Salicornia virginica* | Virginia glasswort | OBL | Native |
| *Spergularia Canadensis* | Canada sandspurry | FACW | Native |
| *Thuja plicata* | western red cedar | FAC | Native |
| *Triglochin maritimum* | seaside arrow-grass | OBL | Native |

Twenty-five bird species from 18 avian families were present during surveys at the Harper reference site from April through July 2001. Table C-2 lists species recorded during surveys in 2001. Birds are assigned an upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1988), and Smith et al. (1997).

**Table C-2 Harper Reference Site Bird Survey List** (April – July 2001).

| **Family Name**[18] | **Common Name** | **Scientific Name** | **Status** |
|---|---|---|---|
| *Anatidae* | Mallard | *Anas platyrhynchos* | wetland-dependent |
| | Green-winged Teal | *Anas crecca* | wetland-dependent |
| *Ardeidae* | Great Blue Heron | *Ardea herodias* | wetland-dependent |
| *Charadriidae* | Killdeer | *Charadrius vociferus* | |
| *Laridae* | Glaucous-winged Gull | *Larus glaucescens* | |
| *Alcedinidae* | Belted Kingfisher | *Ceryle alcyon* | wetland-dependent |
| *Tyrannidae* | Pacific-slope Flycatcher | *Empidonax difficilis* | |
| *Corvidae* | American Crow | *Corvus brachyrhynchos* | |
| *Hirundinidae* | Violet-green Swallow | *Tachycineta thalassina* | |
| | Barn Swallow | *Hirundo rustica* | |
| *Paridae* | Black-capped Chickadee | *Poecile atricapillus* | |
| | Chestnut-backed Chickadee | *Poecile rufescens* | |
| *Troglodytidae* | Bewick's Wren | *Thryomanes bewickii* | |
| *Regulidae* | Ruby-crowned Kinglet | *Regulus calendula* | |
| *Turdidae* | Swainson's Thrush | *Catharus ustulatus* | |
| | American Robin | *Turdus migratorius* | |
| *Sturnidae* | European Starling | *Sturnus vulgaris* | |
| *Bombycillidae* | Cedar Waxwing | *Bombycilla cedrorum* | |

[18] The Harper bird species list follows the American Ornithologists' Union Checklist of North American Birds (AOU 1998). The list incorporates changes made in the 42nd, 43rd, and 44th Supplement to the Checklist, as published in the Auk 117:847-858 (2000); 119:897-906 (2002); and 120:923-932 (2003).

| | | | |
|---|---|---|---|
| *Parulidae* | Orange-crowned Warbler | *Vermivora celata* | |
| | Wilson's Warbler | *Wilsonia pusilla* | |
| *Emberizidae* | Spotted Towhee | *Pipilo maculatus* | |
| | Song Sparrow | *Melospiza melodia* | |
| *Icteridae* | Red-winged Blackbird | *Agelaius phoeniceus* | wetland-dependent |
| *Fringillidae* | House Finch | *Carpodacus mexicanus* | |
| | Pine Siskin | *Carduelis pinus* | |

# Appendix D
# Harper Bird Survey List (2003)

Birds are assigned an upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Species that primarily utilize upland habitats for breeding, nesting, and feeding are considered upland birds. Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1988), and Smith et al. (1997).

**Table D-1 Harper Reference Site Bird Survey Checklist** (April – July 2003).

| **Family Name**[19] | **Common Name** | **Scientific Name** | **Status** |
|---|---|---|---|
| *Ardeidae* | Great Blue Heron | *Ardea herodias* | wetland-dependent |
| *Charadriidae* | Killdeer | *Charadrius vociferus* | |
| *Alcedinidae* | Belted Kingfisher | *Ceryle alcyon* | wetland-dependent |
| *Picidae* | Downy Woodpecker | *Picoides pubescens* | |
| *Tyrannidae* | Willow Flycatcher | *Empidonax traillii* | |
| | Pacific-slope Flycatcher | *Empidonax difficilis* | |
| *Corvidae* | American Crow | *Corvus* brachyrhynchos | |
| *Hirundinidae* | Violet-green Swallow | *Tachycineta thalassina* | |
| | Barn Swallow | *Hirundo rustica* | |
| *Paridae* | Black-capped Chickadee | *Poecile atricapillus* | |
| *Aegithalidae* | Bushtit | *Psaltriparus minimus* | |
| *Sittidae* | Red-breasted Nuthatch | *Sitta canadensis* | |
| *Troglodytidae* | Bewick's Wren | *Thryomanes bewickii* | |
| | Winter Wren | *Troglodytes troglodytes* | |
| *Regulidae* | Ruby-crowned Kinglet | *Regulus calendula* | |
| *Turdidae* | Swainson's Thrush | *Catharus ustulatus* | |
| | American Robin | *Turdus migratorius* | |
| *Bombycillidae* | Cedar Waxwing | *Bombycilla cedrorum* | |
| *Parulidae* | Black-throated Gray Warbler | *Dendroica nigrescens* | upland |
| | Wilson's Warbler | *Wilsonia pusilla* | |
| *Emberizidae* | Spotted Towhee | *Pipilo maculatus* | |
| | Savannah Sparrow | *Passerculus sandwichensis* | |
| | Song Sparrow | *Melospiza melodia* | |
| *Cardinalidae* | Black-headed Grosbeak | *Pheucticus melanocephalus* | |
| *Icteridae* | Red-winged Blackbird | *Agelaius phoeniceus* | wetland-dependent |
| | Brown-headed Cowbird | *Molothrus ater* | |
| *Fringillidae* | House Finch | *Carpodacus mexicanus* | |
| | American Goldfinch | *Carduelis tristis* | |

[19] The Harper bird species list follows the American Ornithologists' Union Checklist of North American Birds (AOU 1998). The list incorporates changes made in the 42nd, 43rd, and 44th Supplement to the Checklist, as published in the Auk 117:847-858 (2000); 119:897-906 (2002); and 120:923-932 (2003).
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# Appendix E
# Schel-chélb Bird Survey List (2003)

The following list includes species recorded during surveys from April through July 2003. Birds are assigned an upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Species that primarily utilize upland habitats for breeding, nesting, and feeding are considered upland birds. Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1988), and Smith et al. (1997).

**Table E-1 Schel-chélb Bird Survey Checklist** (April – July 2003).

| Family Name[20] | Common Name | Scientific Name | Status |
|---|---|---|---|
| *Anatidae* | Canada Goose | *Branta Canadensis* | wetland-dependent |
| | Mallard | *Anas platyrhynchos* | wetland-dependent |
| | Green-winged Teal | *Anas crecca* | wetland-dependent |
| | Bufflehead | *Bucephala albeola* | wetland-dependent |
| | Hooded Merganser | *Lophodytes cucullatus* | wetland-dependent |
| *Phasianidae* | Ring-necked Pheasant | *Phasianus colchicus* | upland |
| *Ardeidae* | Great Blue Heron | *Ardea herodias* | wetland-dependent |
| *Charadriidae* | Killdeer | *Charadrius vociferus* | |
| *Scolopacidae* | Western Sandpiper | *Calidris mauri* | wetland-dependent |
| *Trochilidae* | Rufous Hummingbird | *Selasphorus rufus* | |
| *Alcedinidae* | Belted Kingfisher | *Ceryle alcyon* | wetland-dependent |
| *Picidae* | Downy Woodpecker | *Picoides pubescens* | |
| | Northern Flicker | *Colaptes auratus* | |
| *Tyrannidae* | Willow Flycatcher | *Empidonax traillii* | |
| | Pacific-slope Flycatcher | *Empidonax difficilis* | |
| *Corvidae* | American Crow | *Corvus brachyrhynchos* | |
| *Hirundinidae* | Violet-green Swallow | *Tachycineta thalassina* | |
| | N. Rough-winged Swallow | *Stelgidopteryx serripennis* | |
| | Barn Swallow | *Hirundo rustica* | |
| *Paridae* | Black-capped Chickadee | *Poecile atricapillus* | |
| *Aegithalidae* | Bushtit | *Psaltriparus minimus* | |
| *Troglodytidae* | Bewick's Wren | *Thryomanes bewickii* | |
| | Marsh Wren | *Cistothorus palustris* | wetland-dependent |
| *Regulidae* | Golden-crowned Kinglet | *Regulus satrapa* | |
| *Turdidae* | Swainson's Thrush | *Catharus ustulatus* | |
| | American Robin | *Turdus migratorius* | |
| *Sturnidae* | European Starling | *Sturnus vulgaris* | |
| *Bombycillidae* | Cedar Waxwing | *Bombycilla cedrorum* | |
| *Parulidae* | Orange-crowned Warbler | *Vermivora celata* | |
| | Yellow Warbler | *Dendroica petechia* | |
| | Yellow-rumped Warbler | *Dendroica coronata* | |

[20] The Schel-chélb Estuary Bird Survey Checklist follows the American Ornithologists' Union Checklist of North American Birds (AOU 1998). The list incorporates changes made in the 42nd, 43rd, and 44th Supplement to the Checklist, as published in the Auk 117:847-858 (2000); 119:897-906 (2002); and 120:923-932 (2003).

**Schel-chélb Estuary 2003 Bird Survey List (cont.)**

| Family Name | Common Name | Scientific Name | Status |
|---|---|---|---|
| *Emberizidae* | Spotted Towhee | *Pipilo maculates* | |
| | Savannah Sparrow | *Passerculus sandwichensis* | |
| *Emberizidae* | Song Sparrow | *Melospiza melodia* | |
| *Cardinalidae* | Black-headed Grosbeak | *Pheucticus melanocephalus* | |
| *Icteridae* | Red-winged Blackbird | *Agelaius phoeniceus* | wetland-dependent |
| *Fringillidae* | Purple Finch | *Carpodacus purpureus* | |
| | House Finch | *Carpodacus mexicanus* | |
| | Pine Siskin | *Carduelis pinus* | |
| | American Goldfinch | *Carduelis tristis* | |
| *Passeridae* | House Sparrow | *Passer domesticus* | upland |

## Schel-chélb Estuary Checklist of Birds

Birds from this list were recorded during survey and non-survey monitoring events from 1997 through 2003. Bainbridge Island residents and members of the local Audubon Society including Ian Paulsen, Gale Cool, George Gerdts, Lee Robinson, Jamie Acker, and Eric Hoffman have made additional contributions. An asterisk identifies their contributions to this checklist.

**Waterfowl**
Greater White-fronted Goose (*Anser albifrons*)*
Canada Goose (*Branta canadensis*)
American Widgeon (*Anas americana*)
Mallard (*Anas platyrhynchos*)
Blue-winged Teal (*Anas discors*)
Northern Shoveler (*Anas clypeata*)*
Green-winged Teal (*Anas crecca*)
Bufflehead (*Buecephla albeola*)

**Upland Gamebirds**
Ring-necked Pheasant (*Phasianus colchicus*)

**Herons**
Great Blue Heron (*Ardea herodias*)
Green Heron (*Butorides striatus*)

**Diurnal Raptors**
Osprey (*Pandion haliaetus*)
Bald Eagle (*Haliaeetus leucocephalus*)
Red-tailed Hawk (*Buteo jamaicencis*)

**Falcons**
Merlin (*Falco columbarius*)

**Plovers**
Killdeer (*Charadrius vociferous*)

**Sandpipers and Allies**
Greater Yellowlegs (*Tringa melanoleuca*)
Solitary Sandpiper (*Tringa solitaria*)*
Spotted Sandpiper (*Actitus macularia*)
Sanderling (*Calidris alba*)
Semipalmated Sandpiper (*Calidris pusilla*)*
Dunlin (*Calidris alpina*)
Western Sandpiper (*Calidris mauri*)
Least Sandpiper (*Calidris minutilla*)
Long-billed Dowitcher (*Limnodromus scolopaceus*)*
Wilson's Snipe (*Gallinago delicata*)*

**Gulls**
Ring-billed Gull (*Larus delawarensis*)
Glaucous-winged Gull (*Larus glaucescens*)

**Pigeons and Doves**
Band-tailed Pigeon (*Columba fasciata*)
Mourning Dove (*Zenaida macroura*)

**Hummingbirds**
Rufous Hummingbirds (*Selasphorus rufus*)

**Kingfishers**
Belted Kingfisher (*Ceryle alcyon*)

**Woodpeckers**
Northern Flicker (*Colaptes auratus*)
Red-breasted Sapsucker (*Sphyrapicus ruber*)
Downy Woodpecker (*Picoides pubescens*)

**Tyrant Flycatchers**
Olive-sided Flycatcher (*Contopus borealis*)
Willow Flycatcher (*Empidonax traillii*)
Pacific-slope Flycatcher (*Empidonax difficilis*)

**Vireos**
Warbling Vireo (*Vireo gilvus*)

**Crows and Allies**
Stellers's Jay (*Cyanocitta stelleri*)
American Crow (*Corvus brachyrhynchos*)

**Swallows**
Violet-green Swallow (*Tachycineta thalassina*)
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)
Barn Swallow (*Hirundo rustica*)

**Chickadees**
Black-capped Chickadee (*Poecile atricapillus*)

**Bushtits**
Bushtit (*Psaltriparus minimus*)

**Wrens**
Winter Wren (*Troglodytes troglodytes*)
Bewick's Wren (*Thryomanes bewickii*)
Marsh Wren (*Cistothorus palustris*)

**Kinglets**
Golden-crowned Kinglet (*Regulus satrapa*)

**Thrushes**
Swainson's Thrush (*Catharus ustulatus*)
American Robin (*Turdus migratorius*)

**Starlings**
European Starling (*Sturnus vulgaris*)

**Waxwings**
Cedar Waxwing (*Bombycilla cedrorum*)

**Wood Warblers**
Orange-crowned Warbler (*Vermivora celata*)
Yellow Warbler (*Dendroica petechia*)
Yellow-rumped Warbler (*Dendroica coronata*)
Black-throated Gray Warbler (*Dendroica nigrescens*)
Common Yellowthroat (*Geothylypis trichas*)
Wilson's Warbler (*Wilsonia pusilla*)

**Tanagers**
Western Tanager (*Piranga ludoviciana*)

**New World Sparrows and Allies**
Spotted Towhee (*Pipilo maculates*)
Song Sparrow (*Melospiza melodia*)
White-crowned Sparrow (*Zonotrichia leucophrys*)
Dark-eyed Junco (*Junco hyemalis*)

**Grosbeaks**
Black-headed Grosbeak (*Pheucticus melanocephalus*)

**Blackbirds and Allies**
Red-winged Blackbird (*Agelaius phoeniceus*)
Brewer's Blackbird (*Euphagus cyanocephalus*)
Brown-headed Cowbird (*Molothrus ater*)

**Old World Finches and Allies**
Purple Finch (*Carpodacus purpureus*)
House Finch (*Carpodacus mexicanus*)
Pine Siskin (*Carduelis pinus*)
American Goldfinch (*Carduelis tristis*)

**Old World Sparrows**
House Sparrow (*Passer domesticus*)

# Appendix F
# Glossary of Terms

**Abundance (total)** – the total number of individuals, cover, frequency of occurrence, volume, or biomass of a species, or group of species, within a given area.

**Accuracy** – the closeness of a measured or computed value to its true value.

**Adaptive management** – the process of linking ecological management within a learning framework (Elzinga et al. 1998).

**Aerial cover** – is the percent of ground surface covered by vegetation of a particular species (or suite of species) when viewed from above (Elzinga et al. 1998). Values for aerial cover are typically obtained from point-line, point-frame, or line-intercept data.

**Areal estimates** – are made using the known boundary of a feature or statistical population. Areal estimates are often expressed in units of area.

**Aquatic vegetation** – includes submerged and rooted (*Elodea*, *Myriophyllum*) or floating (non-rooted) plants (*Lemna, Azolla, Wolfia*). For compliance purposes, these plants are not included in cover estimates. Vascular, rooted, floating-leaved plants *are* included in cover estimates (e.g., *Nuphar, Potamogeton*).

**Bare ground** – an area that can support, but does not presently support vascular vegetation.

**Canopy cover** – the coverage of foliage canopy (herbaceous or woody species) per unit ground area.

**Community** – a group of populations of species living together in a given place and time.

**Confidence interval (CI)** – is an estimate of precision around a sample mean. A confidence interval includes confidence level and confidence interval half-width.

**Cryptogam** – any of the *Cryptogamia*, an old primary division of plants comprising those without true flowers and seeds including ferns, mosses, and thallophytes (algae, fungi, and lichen).

**Density** – the number of plants per unit area (typically square meters).

**Densitometer –** a hollow T-shaped polyvinyl chloride (PVC) device that includes horizontal and vertical leveling and a mirror to locate a precise vertical point in space either directly above or directly below the densitometer. Target vegetation intersecting the vertical line of sight through the instrument is recorded.

**Herbaceous** – with characteristics of an herb; an annual, biennial, or perennial plant that is leaflike in color or texture, and not woody.

**Hydric soils** – soils formed under the conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register 1994).

**Invasive** – a plant that interferes with management objectives on a specific site at a specific point in time (Whitson et al. 2001). For monitoring purposes, invasive species include those listed on the current County Noxious Weed List, and on a site-by-site basis, other species may be included (such as *Rubus armeniacus* (Himalayan blackberry)).

**Line-segment** – a linear sample unit that is used to measure vegetative cover.

**Macroplot** – usually refers to a relatively large sampling area in which sub-sampling will be conducted, often using quadrats, line-segments or point-lines (Elzinga et al. 1998).

**Open water** – an area intended to be non-vegetated and permanently inundated as described in the site mitigation or planting plan.

**Point-frame** – is a square or rectangular quadrat that consists of a set of identified points used to collect vegetation data.

**Point-intercept device** – a tripod that supports a rod that can be leveled and lowered vertically to intercept target vegetation at an identified point.

**Point-line** – linear series of points comprising a sample unit.

**Point-quadrat (points)** – a single point, used to sample vegetation data. The point quadrat is theoretically dimensionless.

**Population (biological)** – all individuals of one or more species within a specific area at a particular time.

**Population (statistical)** – the complete set of individual objects (sampling units) about which inferences are made.

**Precision** – the closeness of repeated measurements of the same value.

**Quadrat** – an area delimited for sampling flora or fauna; the sampling frame itself.

**Random sampling** – sampling units drawn randomly from the population of interest.

**Relative abundance (birds)** – the number of individuals per unit of sampling effort.

**Relative cover** – the relative cover of a plant species (or suite of species) is the proportion of the target species coverage compared to that of all species in the plant community combined (Brower et al. 1998).

**Restricted random sampling method** – a sampling method that divides the population of interest into equal-sized segments. In each segment, a single sampling unit is randomly positioned. Sampling units are then analyzed as if they were part of a simple random sample (Elzinga et al. 1998).

**Sample** – a subset of the total possible number of sampling units in a statistical population.

**Sample size equations –** use sample mean and standard deviation to determine if data have been collected from enough sample units to meet the sampling objectives.

**Sample standard deviation** – a value indicating how similar each individual observation is to the sample mean.

**Sampling** – the act or process of selecting a part of something with the intent of showing the quality, style, or nature of the whole.

**Sampling objective** – a clearly articulated goal for the measurement of an ecological condition or change value (Elzinga et al. 1998). Sampling objectives provide a complement to success standards and describe the desired level of precision for sampling. Elements of a sampling objective include the desired confidence level and confidence interval half-width, or the acceptable false-change error and acceptable missed-change error level.

**Sampling units** – the individual objects that collectively make up a statistical population.

**Standard deviation** – a measure of how similar each individual observation is to the overall mean value.

**Shrub** – a woody plant which at maturity is usually less than six meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

**Species richness** – the total number of species observed on a site.

**Structures** – any structure that is not expected to support vegetation during the monitoring period. Structures may include habitat structures, rocks, and other artifacts.

**Stratified random sampling method** – the population of interest is divided into two or more groups (strata) prior to sampling. Within each stratum the sample units are the same. Sample units from different strata may or may not be identical. Random samples are obtained within each group (Elzinga et al. 1998).

**Systematic random sampling method** – the regular placement of quadrats, points, or lines along a sampling transect following a random start.

**Transect** – for vegetation surveys, the transect is a line used to assist in the location sample units (point-lines, quadrats, line-segments or frames) across the monitoring study area.

**Tree** – a woody plant that at maturity is usually six meters (20 feet) or more in height and generally has a single trunk, unbranched for one meter or more above ground, and more or less definite crown (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

**Upland species (birds)** - primarily utilizes upland habitat for breeding, nesting, and feeding.

**Vegetation structure** – the physical or structural description of the plant community (e.g. the relative biomass in canopy layers), generally independent of particular species composition.

**Wetland-dependent species (birds)** – restricted in temporal or spatial distribution to wetlands based on an intrinsic feature or features of the environment (Finch 1989).

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